CHEMICAL TREATMENT OF THE PERIOSTEUM IN THORACOPLASTY TO INHIBIT RIB REGENERATION

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Five years ago, Jerome Head[1] described experiments in which he tested the effectiveness of various chemical agents for preventing osteogenesis after subperiosteal costectomy. He removed pieces of several ribs from each of a number of dogs and then painted the rib-free periosteum with the chemicals before closing the wound. After a lapse of time amply sufficient for bone to regenerate, the animals were sacrificed and the rib beds were examined by X-rays and dissection. Zenker's solution seemed the most suitable of the agents employed, since it prevented osteogenesis completely without producing appreciable necrosis. Meiss[2] reported a similar investigation in 1930. Although he found Zenker's solution quite effective in preventing the formation of new bone, he noted perforation into the pleural cavity in one instance and symptoms (undescribed) of systemic poisoning. He preferred 10 per cent. solution of formalin—an agent not tested by Head—for it had all the advantages of Zenker's solution and none of the disadvantages.

Both authors suggested clinical uses for their methods in certain types of thoracoplasty. Thus, it was recalled that where ribs have to be resected in stages for producing collapse of the chest-wall, "the true collapse occurs only with the removal of the last ribs. Until then the part of the wall of the chest which is already mobilized hangs from the ribs like the curtain of a tent, and, if the bones reform in this position, the final collapse is compromised."[1] Furthermore, the lapse of three weeks between the first and last stages of operation may be sufficient to bring about this undesired result, and yet that or even a much greater interval between the stages is often advantageous or imperative, in order to replenish the patient's strength and morale, to prevent advancement of associated diseases, to permit infected wounds to heal, to test the effectiveness of preceding stages, *etc.* It seemed to Meiss that the method would be useful in paravertebral extrapleural thoracoplasty for pulmonary tuberculosis because it would allow wider intervals between the stages of operation and would permit the chest-wall to continue collapsing slightly for several months after operation, in response to the gradual fibrosis and shrinkage of the lung that occurs with the healing of the disease. He believed that the prevention of rib regeneration would not leave the thoracic wall sufficiently unstable to jeopardize the healing of the pulmonary lesion, for he knew of a patient who had received paravertebral thoracoplasty by *supra*periosteal costectomy and had obtained full benefit to the tuberculous lesion of the lung. Head advised against this application

of the method, on the theoretical grounds of mural instability. Other uses suggested by these authors were as follows: Employment in the graded Estlander operation for chronic empyæma or bronchiectasis, to permit wider spacing of the stages and more prolonged collapse; use in the Brauer cardiolysis, to ensure permanent pliability of the precordium; use in the rib resection for drainage of empyæma or lung abscess, to prevent new bone from forming in, and encroaching upon, the sinus; and use in the rib resection for cautery pneumectomy, to obviate the difficulty which may arise from regeneration of bone in the field of cauterization.

Neither one of the authors has reported clinical experience with his method, and the only reference of the kind that I can find is the bare statement of Trout[3] that he had used the method of Head with satisfaction in thoracoplasty for pulmonary tuberculosis. I began to use Zenker's solution in plastic operations for chronic empyæma soon after the appearance of Head's publication, but changed later to formalin. Twelve cases of that type have been treated with one or the other chemical, and, besides, twenty-three cases with drainage of empyæma, three with drainage of lung abscess, and two with cautery pneumectomy. While this experience is quite insufficient for final evaluation of the methods, the results have been satisfactory and consistent enough to warrant preliminary report.

The first case to be treated was that of a white male, aged thirty-two years. At the time of admission to the hospital, he had been ill for eleven months with productive cough, fever, dyspnœa, and weakness. Five months before the symptoms had become so exaggerated that the patient had to stop work. His physician at the time made the diagnosis of empyæma of the left pleural cavity and established drainage by intercostal catheter. Considerable improvement followed, but soon the cough and fever returned. On admission the patient was found to be emaciated, weak, and toxic. The left half of the chest was markedly retracted and fixed, and it exhibited a narrow sinus at the seventh intercostal space in the posterior axillary line. Tubercle bacilli were abundant in the sputum and in the pus from the sinus. X-ray examination showed an empyæma cavity on the left side with very thick walls, extending from the third rib to the diaphragm and from the anterior axillary line to the vertebral column. An operation was done immediately to widen the sinus. A specimen of the pleura which was obtained at the time revealed the presence of tuberculous infection. The drainage thus established and the supportive treatment that followed produced great improvement of the constitutional condition within two months; but the cavity was unchanged in size, so the decision was made to obliterate it with the graded thoracoplasty of Schede. At the first stage, the lower one-third of the roof of the cavity was removed; but the shock was very severe. So, two months later, when the patient's strength was sufficiently restored, the milder operation of Estlander was resorted to, with the addition that the rib-free portions of periosteum were painted with Zenker's solution. The parts of the ribs lying over the cavity, together with a part of one rib (second) above, were removed in two sittings, with an interval of six weeks between to allow for delayed wound healing. The immediate effect of this was only partial obliteration of the empyæma cavity; but the collapse proved to be progressive and fourteen months after the last operation the cavity was closed, the sinus was healed, and the patient felt well.

In the three other cases of tuberculous empyæma treated since then, the entire lengths of the ribs overlying the cavities were removed subperiosteally

in small and widely spaced steps, with application of one or the other chemical to the periosteum. The cavities collapsed satisfactorily, and only one (see the case report below), which was operated upon very recently, has not yet healed. Graded subperiosteal resection of only the posterior segments of ribs was employed for the patients with extensive non-tuberculous empyæma. This included the ribs over the cavity—and one above if the cavity was subtotal. The result was that the anterolateral segments of ribs, the thickened parietal pleura, and the superficial tissues, which remained over the cavity, fell progressively during and after the operations until obliteration was complete. One of these cases required further work, to unroof a small residual cavity. Thus, in both types of empyæma, the Estlander operation almost entirely replaced the Schede procedure, which hitherto had been indispensable. Since the parietal pleura and intercostal structures were not removed, as in the Schede thoracoplasty, the operations were accompanied by relatively little blood loss and shock and by no paralysis of the abdominal wall. A comparatively small but noteworthy advantage of the chemical treatment was that, after resection of the posterior segments of ribs, the posterior ends of the anterolateral segments developed no spurs.* No appreciable disadvantage was experienced from paradoxical respiratory movements of the chest-wall. Scoliosis developed, but it was no greater—indeed, usually much less—than that after Schede resections for equally extensive cavities. Chemical poisoning was watched for but was not detected. Chronic empyæma cavities, which were so small as to extend under no more than three ribs, were still treated by the Schede thoracoplasty.

The expected benefits were derived, also, in connection with rib resection in the other types of cases. Although the benefits were comparatively slight, they were worth while.

One case was outstanding, because it made possible a direct comparison between Zenker's and formalin solutions as to their effectiveness in preventing osteogenesis.

A Chinese male, aged twenty-three years, was admitted to the hospital with a history of productive cough for two and one-half years. Slight weakness was the only accompanying symptom, until one day three months before when, during unusually strenuous coughing, sudden pain occurred in the right side of the chest and marked dyspnœa developed. He took to bed at once and soon had a chill and started to run a high fever. On admission the man was extremely emaciated and feeble, orthopnœic, cyanotic, and disturbed by a frequent productive cough. The sputum was fetid and contained myriads of tubercle bacilli. Physical and röntgenographical examination of the chest revealed complete collapse of the right lung, fluid and air in the right pleural cavity, extensive displacement of the mediastinum to the left, depression of the right hemidiaphragm, and a light infiltration of the left upper lobe which was suspected to be tuberculous. The chest was tapped. The fluid proved to be thick pus, containing tubercle bacilli, streptococci, staphylococci, and other organisms, and the air was found to be under pressure of plus 3 to 8 centimetres H_2O. The initial treatment consisted

* Hedblom[4] has emphasized the danger of laceration of the pleura and lung that exists during anterolateral costectomy for pulmonary tuberculosis, in removing ribs that carry these sharp, upward curved projections.

in bi-daily aspiration of large quantities of pus and air and in general supportive measures. Within four weeks the dyspnœa was greatly relieved and the mediastinum was returned to the mid-position (Fig. 1); but the secondary infection and fever persisted, so that open drainage was done. At the same operation, ten centimetres of each of ribs 11, 10 and 9 were resected paravertebrally and the rib-free periosteum was painted with Zenker's solution, which constituted the first stage of an Estlander operation to de-rib the entire right half of the chest. The paravertebral wound became infected slightly from its close proximity to the drainage wound. The operation was well borne, nevertheless, so it was decided not to wait for complete healing of the paravertebral incision but to abandon the usual orderly progression of resection and operate the second time at a considerable distance. Consequently, the second stage was performed twenty-six days after the first and consisted in the resection of four to ten centimetres of the posterior extremities of ribs 4 to 1, inclusive, with application of Zenker's solution. The wound healed well. But shortly after this, the temperature became somewhat elevated, the cough increased, and a röntgenogram (Fig. 2) showed

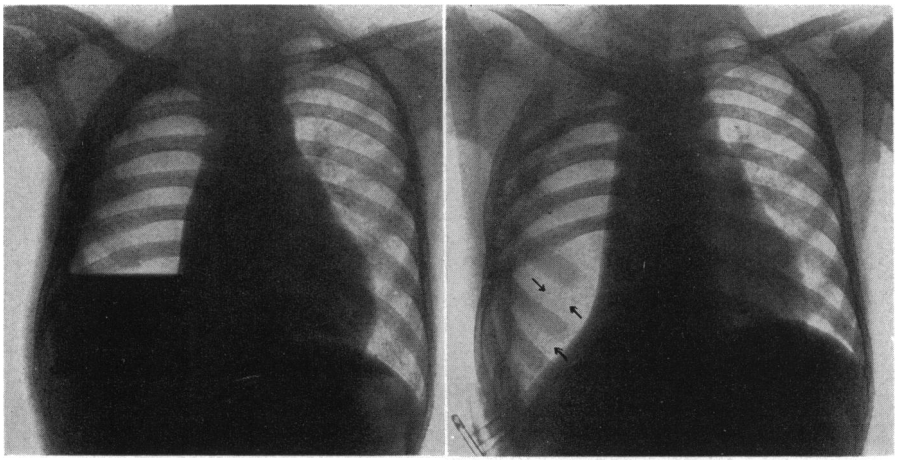

FIG. 1. FIG. 2.

FIG. 1.—Thoracic röntgenogram of a case with secondarily infected, tuberculous empyæma and complete collapse of one lung, taken just before the beginning of a graded subperiosteal costectomy wherein Zenker's and formalin solutions were compared for effectiveness in preventing rib regeneration.

FIG. 2.—Same case, thirty-six days after the establishment of open drainage and the resection of the posterior segments of ribs 11 to 9, and ten days after the resection of the posterior segments of ribs 4 to 1. The rib-free periosteum was painted with Zenker's solution. Arrows indicate the foci of new bone from the first operation.

a slight increase in the lesion of the left lung. The same röntgenogram was interesting from the fact that it gave an exceptionally distinct view of the beds of some of the resected ribs—due to the persistence of a bridge of ribs (8 to 5) across the middle of the hemithorax which held the beds widely out—and that it showed definite traces of new bone in the field of the first operation performed thirty-six days previously. The infection in the left lung quieted sufficiently to permit the third stage to be performed fifty-one days after the second, with removal of the anterolateral segments of the upper four ribs; but this time 10 per cent. solution of formalin was used in place of Zenker's solution, according to Meiss' suggestion. The wound healed *per primam*. And once more the condition of the left lung demanded a long wait. A röntgen-film (Fig. 3), taken fifty days after the third stage, showed that the formalin-treated periosteum was free from appreciable amounts of new bone, while the Zenker's treated periosteum of the first operation (127 days before) had developed incomplete but well-defined ribs. The field of the second operation lay too close to the spine to permit clear

discernment of the degree of rib regeneration. The fourth operation came the day after this examination and the fifth came twenty-seven days later, whereby the remaining ribs and portions of ribs were taken out and the periosteum was painted with formalin. Figure 4 gives the appearance ten days after the last operation when the chest-wall was completely collapsed and the merest slit remained of the empyæma cavity. The patient's condition was satisfactory in other respects, also. The cough was absent, the temperature normal, the pulse rate only slightly elevated, and the body weight increased by four kilograms. The lesion of the left lung seemed about the same as at admission. A prolonged period of rest was then indicated, to permit that infection and the one in the collapsed empyæma cavity to heal, but the prognosis was fair.

The results in this case suggest that formalin is much more effective than Zenker's solution. In view of the fact that the collapse of the chest was complete, both in this and in the other cases treated with Zenker's solution, it is very likely that the ribs which regenerated after the use of that agent were

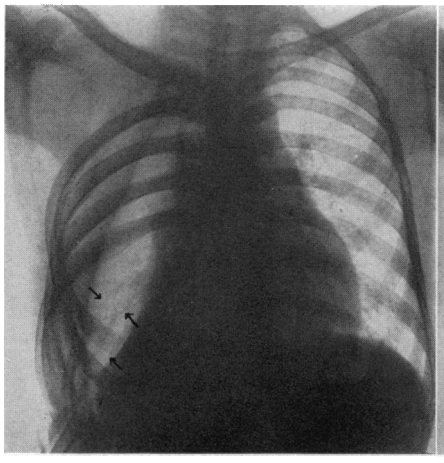

FIG. 3.

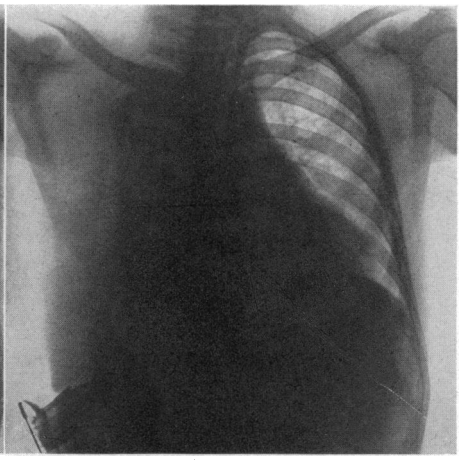

FIG. 4.

FIG. 3.—Same case, fifty days after the resection of the anterolateral segments of ribs 4 to 1 with application of formalin solution (third costectomy). No new bone is visible. Arrows indicate the enlarged, fragmentary deposits of bone 127 days after the first operation.
FIG. 4.—Same case, five months and five days after the first and ten days after the last (fifth) costectomy. Ribs 11 to 1 are absent and the empyæma cavity is totally collapsed.

fragmentary rather than solid. Although formalin seemed to prevent osteogenesis entirely in the instance cited above, proof has since appeared that it permits a slight amount of bone to form. In a case being treated at present by cautery pneumectomy, the slough of the thoracic wall from the first burning contained tiny spicules of bone along the lines of the periosteal beds which had been stripped of ribs and painted with formalin thirty-six days before the burning. The partial regeneration that occurs after both agents probably accounts for the satisfactory degree of stability of the chest-wall that resulted in all of the cases of chronic empyæma. Furthermore, it suggests that the method of periosteal treatment can be applied to paravertebral thoracoplasty for pulmonary tuberculosis without danger of instability of the thorax. This will soon be tested, first with Zenker's solution.

The solutions were applied as follows. After each rib was removed, its

periosteum was sponged free from blood and then wiped throughout with a small gauze swab, which had been dipped in the solution and shaken out. The periosteum was again sponged dry and painted with a fresh swab; and the process was repeated five or six times. This insured that the rib bed received thorough contact with the agent, without much contamination of the surrounding tissues.

SUMMARY.—The discoveries of Head and Meiss are recounted, that bone regeneration after subperiosteal costectomy in dogs can be prevented completely by application to the periosteum of Zenker's or formalin solution, as well as the suggestions of these authors as to possible clinical applications. Personal experience with both agents for this purpose is briefly reported, which concerned forty-three clinical cases, including twelve with chronic empyæma. It is concluded that, in man, both solutions inhibit the reformation of bone markedly but do not prevent it entirely, that formalin is much the more effective, and that the use of one or the other of these chemicals is advantageous in certain operations of rib resection. The chief advantages occur in the treatment of large chronic empyæma cavities, because the Estlander thoracoplasty can be used in place of the more destructive and shock-producing procedure of Schede, the stages of resection can be placed as far apart as desired, spurs do not form on the ribs, the chest-wall continues to collapse long after the last operation.

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